Center Independent Research & Development: GSFC IRAD

Normal-Incidence X-ray Mirror

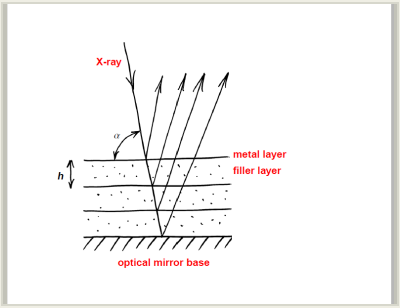
Completed Technology Project (2017 - 2021)

Project Introduction

This effort focuses on the development of a novel normal-incidence X-ray mirror using multilayer reflective coating. The first step is to demonstrate the feasibility of normal-incidence X-ray imaging at E~0.5 keV. While such mirrors exist in the FUV (E<0.1-0.15 keV), so far this approach has not been used at higher energies, because the layers of the multilayer coating must be very thin and their boundaries very sharp and regular. The team is trying to use ALD to coat small polished glass samples (flat plates and off-the-shelf optical concave mirrors) with several types of multilayers using in-house and commercial ALD facilities. Measurements of the peak reflectivity and the width of the energy response are being done in-house using a monochromatic source at the varying incidence angle. Angular resolution of the coated concave mirror will be measured using in-house facilities and detectors. Additionally, a mission study that would utilize this mirror has been done at Wallops MPL.

Anticipated Benefits

This effort focuses on the development of an innovative normal-incidence X-ray mirror for E~0.5 keV using a multilayer coating. Such mirror would reflect in a predefined very narrow (a few eV) energy interval, effectively enabling soft X-ray imaging spectroscopy with high energy and angular resolution (perhaps ~1") on the cheap, though for only one energy bin at a time. Such a technology, perhaps hosted on a Pioneer class mission, could obtain the first-ever images of warm gaseous circumgalactic halos – a theoretically predicted reservoir of "missing baryons" in the low-redshift universe. The proposed narrow-band mirror will help separate the expected very faint redshifted signal from the galaxies and the much brighter, zero-redshift oxygen line from the Milky Way.



Principle of normal-incidence X-ray reflection using multilayer coating

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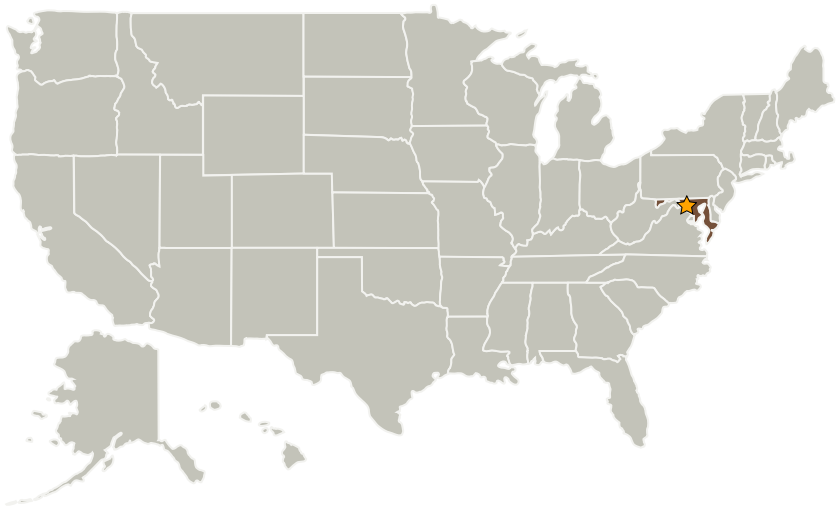
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
University of Maryland-College Park(UMCP)	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	College Park, Maryland

Primary U.S. Work Locations
Maryland

Project Transitions

October 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Mission Support Directorate (MSD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:

Peter M Hughes

Project Managers:

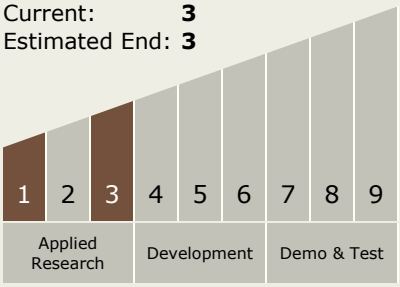
Keith M Jahoda
David H Richardson

Principal Investigator:

Maxim L Markevitch

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



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September 2021: Closed out

Closeout Summary: We have defined the requirements for an X-ray reflective multilayer for our wavelength and selected suitable candidate material pairs for the high and low-density layers, based on ALD literature. Several materials have been tried using commercial ALD providers; we have also explored the depositio n process parameters for some materials using an ALD reactor at UMD. It appea rs to be possible to achieve the required layer smoothness using ALD. In order t o try to deposit interesting material pairs using interesting deposition methods, we have successfully built a small, specialized ALD reactor for thermal and plas ma-assisted deposition at Goddard. Due to the covid lab closure and the subseq uent (still ongoing) long delays for part deliveries from commercial vendors, whil e the reactor is near-complete, we have not yet started depositions as of the clo sure of the project, but work will continue using external funding. We expect it t o result in a successful multilayer coating that has useful reflectivity at E=500-6 00 eV at normal incidence. The purpose of the Goddard Space Flight Center's Int ernal Research and Development (IRAD) program is to support new technology development and to address scientific challenges. Each year, Principal Investiga tors (PIs) submit IRAD proposals and compete for funding for their development projects. Goddard's IRAD program supports eight Lines of Business: Astrophysi cs; Communications and Navigation; Cross-Cutting Technology and Capabilities; Earth Science; Heliophysics; Planetary Science; Science Small Satellites Technol ogy; and Suborbital Platforms and Range Services. Task progress is evaluated t wice a year at the Mid-term IRAD review and the end of the year. When the fun ding period has ended, the PIs compete again for IRAD funding or seek new sou rces of development and research funding, or agree to external partnerships an d collaborations. In some cases, when the development work has reached the a ppropriate Technology Readiness Level (TRL) level, the product is integrated int o an actual NASA mission or used to support other government agencies. The te chnology may also be licensed out to the industry. The completion of a project d oes not necessarily indicate that the development work has stopped. The work could potentially continue in the future as a follow-on IRAD; or be used in collab oration or partnership with Academia, Industry, and other Government Agencie s. If you are interested in partnering with NASA, see the TechPort Partnerships d ocumentation available on the TechPort Help tab. http://techport.nasa.gov/help

Technology Areas

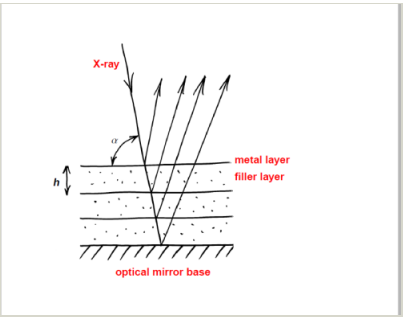
Primary:

- TX08 Sensors and Instruments
  - TX08.2 Observatories
    - TX08.2.1 Mirror Systems

Target Destination

Outside the Solar System

Images



Principle of normal-incidence X-ray reflection using multilayer coating
Principle of normal-incidence X-ray reflection using multilayer coating *(https://techport.nasa.gov/image/102494)*

Links

NASA Goddard Facebook
(https://www.facebook.com/NASA.GSFC)

NASA Goddard Science and Exploration Directorate
(http://sciences.gsfc.nasa.gov/sed/)

NASA Goddard Twitter
(https://twitter.com/intent/follow?screen_name=NASAGoddard)

Project Website:

http://www.nasa.gov/centers/goddard/home/index.html